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## **Freshwater mussels of the Embarras River basin and minor Wabash tributaries in Illinois**

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2012

Illinois Natural History Survey, Prairie Research Institute, University of Illinois  
Illinois Department of Natural Resources

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## **Preface**

While broad geographic information is available on the distribution and abundance of mussels in Illinois, systematically collected mussel-community data sets required to integrate mussels into aquatic community assessments do not exist. In 2009, a project funded by a US Fish and Wildlife Service State Wildlife Grant was undertaken to survey and assess the freshwater mussel populations at wadeable sites from 33 stream basins in conjunction with the Illinois Department of Natural Resources (IDNR)/Illinois Environmental Protection Agency (IEPA) basin surveys. Inclusion of mussels into these basin surveys contributes to the comprehensive basin monitoring programs that include water and sediment chemistry, instream habitat, macroinvertebrate, and fish, which reflect a broad spectrum of abiotic and biotic stream resources. These mussel surveys will provide reliable and repeatable techniques for assessing the freshwater mussel community in sampled streams. These surveys also provide data for future monitoring of freshwater mussel populations on a local, regional, and watershed basis.

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## **Introduction**

Freshwater mussel populations have been declining for decades and are among the most seriously impacted aquatic animals worldwide (Bogan 1993, Williams et al. 1993). It is estimated that nearly 70% of the approximately 300 North American mussel taxa are extinct, federally-listed as endangered or threatened, or in need of conservation status (Williams et al. 1993, Strayer et al. 2004). In Illinois, 25 of the 62 extant species (44%) are listed as threatened or endangered (Illinois Endangered Species Protection Board 2011). While broad geographic information is available on the distribution and abundance of mussels in Illinois, systematically collected mussel community data sets required to integrate mussels into aquatic community assessments do not exist. The Embarras River basin has been the subject of several previous surveys and publications including M. A. Matteson (1956 survey), Wetzel et al. (1987), and Cummings et al. (1988). The information in Wetzel et al. (1987) is based on Cummings et al. (1988) collection data at one locality. No published information exists on the tributaries to the Embarras River or the other minor Wabash tributaries covered in this report, however sporadic sampling efforts have been conducted in this region. This report summarizes the mussel surveys conducted in the Embarras River basin and minor Wabash tributaries from 2009 to 2011 in conjunction with IDNR and IEPA basin surveys.

The Embarras River basin and minor Wabash tributaries drain an area of approximately 8575 km<sup>2</sup> (3311 mi<sup>2</sup>) in south central Illinois encompassing parts of 13 counties. The three main counties include Edgar, Clark, and Crawford, while parts of Champaign, Douglas, Coles, Cumberland, Jasper, Richland, Lawrence, Wabash, Edwards and White counties are included in this basin (Page et al. 1992). The drainage lies within three natural divisions, Grand Prairie, Southern Till Plain, and Wabash Border (Schwegman 1973). The topography of the drainage varies from flat lands in the upper reaches, rolling country in the mid section, then back to relatively flat lands as the Embarras and the minor tributaries enter the Wabash River (Page et al. 1992). The only major tributary of the Embarras River is the North Fork Embarras, which drains approximately 803 km<sup>2</sup> (310 mi<sup>2</sup>) (Durham 1993, Figure 1).

## **Land-use and Instream Habitat**

Nearly 90% of the Embarras River basin is agricultural land, mainly row crop with a small percentage of grassland. Approximately 10% of the basin is forest or woodland and 5% is urban (Durham 1993, Illinois Department of Agriculture 2000). Only two cities, Charleston and Mattoon, located in the upper portion of the basin, have populations greater than 15,000 residents (US Census Bureau 2010). The mainstem of the Embarras has been impounded in Charleston to form Lake Charleston (Durham 1993, Page et al. 1992). The threats to water

quality in this basin include agriculture, municipal, industrial, and oil production discharges. However, as a whole, the basin is not as heavily polluted as other basins throughout the state (Durham 1993, Page et al. 1992). In 1977, Evers and Page stated that the middle portion of the Embarras was unpolluted, mostly unmodified, and represented one of the finest aquatic natural areas remaining in Illinois due to its wide variety of habitats and rich species diversity (Figure 2). Unfortunately, the wooded floodplain along the river noted in the previous paper was removed in many areas during the late 1970's to increase available acreage for agriculture (Durham 1993).

The substrates in most of the streams of this basin are dominated by sand and gravel. Several different habitat types are common in this basin including gravel and sand bars, riffles, and silt bottomed pools. Excessive sand deposits are located in the lower reaches of the Embarras basin (Figure 3) and silt and clay substrates dominated the lower portion of the minor Wabash tributaries. Most of the sites in the basin had wadeable water depths; however, we limited sampling sites on the lower portion of the Embarras River mainstem due to non-wadeable water depths (e.g., depth>1m).

## Methods

During the 2009-2011 survey, freshwater mussel data were collected at 51 sites; these include 12 minor Wabash tributaries and 39 located in the Embarras River basin (Figure 1; Table 1). Locations of sampling sites are listed in Table 1 along with information regarding IDNR/IEPA sampling at the site. In most cases, mussel survey locations were the same as IDNR/IEPA sites. Live mussels and shells were collected at each sample site to assess past and current freshwater mussel occurrences. Live mussels were surveyed by hand grabbing and visual detection (e.g., trails, siphons, exposed shell) when water conditions permitted. Efforts were made to cover all available habitat types present at a site including riffles, pools, slack water, and areas of differing substrates. A four-hour timed search method was implemented at most sites and a 16-hour survey was completed at five sites to fulfill the sampling objectives for a separate project (Table 1). Live mussels were held in the stream until processing.

Following the timed search, all live mussels and shells were identified to species and recorded (Table 2). For each live individual, shell length (mm), gender, and an estimate of the number of growth rings were recorded. Shell material was classified as recent dead (periostracum present, nacre pearly, and soft tissue may be present) or relict (periostracum eroded, nacre faded, shell chalky) based on condition of the best shell found. A species was considered extant at a site if it was represented by live or recently dead shell material (Szafoni 2001). The nomenclature employed in this report follows Turgeon et al. (1998) except for recent taxonomic changes to the gender ending of purple lilliput and lilliput (*Toxolasma lividum* and *T.*

*parvum*), which follows Williams et al. (2008; Appendix 1). Voucher specimens were retained and deposited in the Illinois Natural History Survey Mollusk Collection. All non-vouchered live mussels were returned to the stream reach where they were collected.

Parameters recorded included extant and total species richness, presence of rare or listed species, and individuals collected, expressed as catch-per-unit-effort (CPUE; Table 2). A population was considered to indicate recent recruitment if individuals less than 30 mm in length or with 3 or fewer growth rings were recorded. Finally, mussel resources were classified as Unique, Highly Valued, Moderate, Limited, or Restricted (Table 2) based on the above parameters (Table 3) and following criteria outlined in Table 4 (Szafoni 2001).

## Results

### Species Richness

A total of 38 species of freshwater mussels were observed in the Embarras and direct Wabash tributaries, 34 of which were live (Table 2). Across all sites, the number of live and extant (live + dead) species collected ranged from 0 to 14, and the total number of species collected (live + dead + relict) ranged from 0 to 18. Tributaries, with the exception of East Branch Embarras, Brushy Fork, and two sites on North Fork Embarras, contained fewer species than the mainstem, with 0 to 9 live and extant species, and 0 to 12 total species. The white heelsplitter (*Lasmigona complanata*), was the most widespread and was collected at 51% of all sites sampled (Figure 4). The plain pocketbook (*Lampsilis cardium*), lilliput, fatmucket (*Lampsilis siliquoidea*) and fragile papershell (*Leptodea fragilis*) were other commonly occurring species (Figure 4), occupying between 30% and 40% of the sites.

### Abundance and Recruitment

A total of 2404 individuals were collected across 51 sites. The number of live specimens collected at a given site ranged from 0 to 234, with an average of 47 mussels per site (Table 2). A total of 204 collector-hours were spent sampling with an average of 12 mussels collected per hour. Thirty-one sites yielded more than 10 individuals and 14 of those 31 sites yielded more than 60 live individuals. The most common species collected in the basin were the fatmucket (n=374), plain pocketbook (n=270), pimpleback (*Quadrula pustulosa*; n=236), giant floater (*Pyganodon grandis*; n=229), white heelsplitter (n=157), Wabash pigtoe (*Fusconaia flava*; n=154), and lilliput (n=152), which together comprised approximately 65% of the collections (Table 2). Mussel abundance at individual sites ranged from none to high, with CPUE ranging from 0 - 58 individuals/collector-hour (Table 2). Extant mussel populations were found at 80% of the sites sampled (41 of 51).

Recruitment for each species was determined by the presence of individuals less than 30 mm or

with 3 or fewer growth rings. Smaller (i.e., younger) mussels are harder to locate by hand grab methods and large sample sizes can be needed to accurately assess population reproduction. However, a small sample size can provide evidence of recruitment if it includes individuals that are small or possess few growth rings. Alternatively, a sample consisting of very large (for the species) individuals with numerous growth rings suggests a senescent population.

Recruitment at individual sites ranged from none observed to high across the basin. Recruitment levels, referred to in Table 3 as Reproduction Factor, varied from 1 to 4, with 19 sites exhibiting moderate to high recruitment. Recruitment was 30 to 50% at 9 sites (8, 33, 37, 39, 42, 46, 48, 50, and 51; Figure 5). Ten other sites exhibited moderate recruitment, while no observed recruitment was recorded at 32 sites during this survey.

### **Mussel Community Classification**

Based on the data collected in the 2009-2011 basin surveys, over 50% of the sites in the Embarras River and minor Wabash tributaries are classified as Moderate, Highly Valued, or Unique mussel resources under the current MCI classification system (Table 4, Figure 5). The Embarras mainstem site (19) near Oakland stands out as a Unique resource due to the presence of intolerant species, the number of mussels collected, and the species richness of the site. Twelve additional sites were classified as Highly Valued and 14 sites were ranked as Moderate mussel resources. The 24 remaining sites were considered Limited or Restricted mussel resources.

### **Noteworthy Finds**

This survey collected 34 live species and 38 total species; historically 49 species were known from the Embarras River and minor Wabash tributaries (Tiemann et al. 2007). Twelve species known historically from this basin not collected during this survey include the flat floater (*Anodonta suborbiculata*), salamander mussel (*Simpsonaias ambigua*), ebonyshell (*Fusconaia ebena*), sheepnose (*Plethobasus cyphus*), clubshell (*Pleurobema clava*), rabbitsfoot (*Quadrula cylindrica*), monkeyface (*Quadrula metanevra*), fanshell (*Cyprogenia stegaria*), butterfly (*Ellipsaria lineolata*), snuffbox (*Epioblasma triquetra*), black sandshell (*Ligumia recta*), and rayed bean (*Villosa fabalis*). All but one of these species is federally or state listed, or species of greatest need of conservation (SGNC) in Illinois.

Five species, the slippershell (*Alasmodonta viridis*), purple wartyback (*Cyclonaias tuberculata*), spike (*Elliptio dilatata*), pyramid pigtoe (*Pleurobema rubrum*), and round hickorynut (*Obovaria subrotunda*) were only represented by relict shell and are all state endangered or threatened species. The relict shell of pyramid pigtoe is the first record for this species in the Embarras River basin, although it has been found in the adjacent Little Wabash River basin. Four of the 21 listed species (federal, state), or SGNC, known historically from the basin were collected live.

An individual rock pocketbook (*Arcidens confragosus*, SGNC), 2 kidneyshells (*Ptychobranchnus fasciolaris*, SE, Figure 6) and purple lilliputs (SE, Figure 7) and 16 little spectaclecases (*Villosa lienosa*, ST) were collected in the basin during our surveys.

## Discussion

Two mussel community assessments have been completed previously in the Embarras River basin. M.R. Matteson conducted surveys at 21 sites in 1956 and K.S. Cummings repeated surveys at those sites plus an additional 4 sites in 1986 and 1987 (Cummings et al. 1988). Nine sites sampled by Matteson/Cummings were sampled during our survey (Sites 9, 13, 19, 25, 31, 33, 36, 37, and 45). Three of these nine sites (25, 33, and 37) were sampled only by Cummings. Varying results were found during the comparison of these three surveys in which 23 species were found in common. In 1956, 27 live species were detected, whereas 25 live species were detected at common sites in 1986/87 and 2009-2011. Thirty total species were reported in 1988 and 31 were recorded in 2009-2011.

In comparing his survey to Matteson, Cummings noted that five species collected in 1956 were not found live during his surveys. However three of the five species, lilliput, rainbow, and little spectaclecase, were collected in low numbers (fewer than four individuals) in 1956 (Table 5). During our survey, only lilliput was found alive at the common locations with rainbow and little spectaclecase being represented by relict shell. However, at several other sites in our surveys, little spectaclecase (n=16) was detected live and lilliput (n=164) was the 7<sup>th</sup> most common species in the basin. In 1956, round hickorynut was the 8<sup>th</sup> most common species and collected at 12 sites. No live individuals of this species were collected in 1986/1987 or during our surveys; relict shell was collected at one site in the 2009-2011 survey. Reduction of this species has also occurred in the Vermilion River drainage leading to the belief that the species is likely extirpated in Illinois (Tiemann et al. 2007).

Two species, found by Matteson and Cummings, monkeyface and snuffbox, were not detected at any sites during our survey. In total, these two surveys found five monkeyface and nine snuffbox at site 19. In 2007/2008, a species specific survey was conducted in the Embarras basin for snuffbox (Tiemann 2010). The sampling effort located only five adult individuals at two sites, and the author suggested that this species should be considered functionally extirpated in Illinois. Two new live species, deertoe and washboard were collected by Cummings and in our surveys. Threehorn wartyback was also detected live during our survey. These species are fairly widespread and common throughout the state (Cummings and Mayer 1992). However, threehorn wartyback seems to be expanding its range in this basin as historically it was only known from the lower reaches of the Embarras but was detected in the mid section (sites 33 and 36) of the basin during our survey. Represented by one individual at

one site (36) in 1956 and 2011, paper pondshell (*Utterbackia imbecillis*) appears to be very rare in the Embarras basin. Lack of suitable habitat, such as sluggish mud bottom pools in the basin, could be the limiting factor for this otherwise widespread and locally-abundant mussel.

Based on a comparison of the previous surveys to the 2009-2011 survey, it appears that the dominant species have changed over time (Table 5). For example, the three most common species at the shared sites in 1956 were mapleleaf (n=191), wartyback (n=151), and plain pocketbook (n=138); in 1988, plain pocketbook (n=60), pimpleback (n=33) and fragile papershell (n=18) were the most dominant. During our survey, pimpleback (n=147), round pigtoe (n=87), and pistolgrip (n=43) were the most common. Several explanations could be speculated for these species differences including changes to the dominant substrate, sampling condition (e.g., water temperature or depth), or fish species composition.

Based on these surveys, we identified several species that may be extirpated in the Embarras River basin. Live or dead occurrences for the salamander mussel, sheepsnose, clubshell, rabbitsfoot, fanshell, butterfly, black sandshell, round hickorynut, and rayed bean were not located during this survey or recent past surveys. Relict shell of the round hickorynut was found in the Embarras mainstem below Lake Charleston Dam. Page et al. (1992) reported that the sheepsnose, rabbitsfoot, fanshell, and round hickorynut were presumed extirpated from the basin. Salamander mussel and rayed bean were found alive in the early 1950's; clubshell, butterfly, and black sandshell had been recorded as relict shell only. The range of several of these species is limited to the Wabash River drainage, which encompasses the Embarras and minor Wabash tributaries, while others such as sheepsnose and black sandshell occur statewide but are uncommon or rare in throughout their range (Cummings and Mayer 1992). All of these species are or were state or federally listed and all are presumed extirpated from the basin.

## **Recruitment**

Over 60% of sites sampled (32 of 51) displayed no recent recruitment. However, mainstem Embarras sites displayed moderate to high recruitment with the exception of the furthest upstream and two furthest downstream sites. Recruitment was also moderate to high in nearly 50% of the North Fork Embarras River sites and the minor Wabash tributaries. These findings suggest that the mussel communities of the mainstem Embarras, North Fork Embarras, and minor Wabash tributaries are viable and self-maintaining at this time. Across all sites only 25% of the mussels collected during these basin surveys were less than 10 years old (i.e., counted rings were less than 10). Mussel populations in these streams may not be recruiting new mussels and this raises concerns about the viability of mussel communities. Sampling methods to target juvenile mussels would be necessary to better assess the reproductive status of these populations.

## **Mussel community of the Embarras River basin**

Our surveys documented the existence of 34 extant and 38 total species in the Embarras River and minor Wabash tributaries. While these numbers are less than the historical species count (49), they are nearly the same as the mussel communities documented by Matteson (1956) and Cummings (1988). In past biological assessments of the Embarras River basin, Smith (1971) rated the middle section of the Embarras River as one of Illinois “Outstanding” streams. Bertrand et al. (1996) ranked only Riley Creek as an Unique Aquatic Resource (“A” stream), while approximately 33% of stream miles within the basin were classified as “B” streams (Highly Valued Aquatic Resource) and greater than 60% were considered Moderate Aquatic Resources (“C” streams) based on fish community data. The mainstem Embarras between Crooked Creek and Whetstone Creek, Brushy Fork, and Hickory Grove were considered Highly Valued Aquatic Resources. Based on our surveys, the mussel communities within these streams would also be considered Highly Valued. However, the mussel communities upstream of Whetstone Creek to East Branch Embarras were also considered Unique to Highly Valued; this part of the river was considered a Moderate Aquatic Resource for fish. Cummings et al. (1988) reported that the sites with the greatest mussel diversity were located in the middle portion of the basin and the present survey largely confirmed those findings.

In more recent assessments of the basin by IEPA biologists, only 17 sites that were sampled for mussels in the basin are considered full support and 4 sites are listed as impaired for aquatic life use based on biological, physiochemical, physical habitat, and toxicity data collected (IEPA 2010). There seems to be a slightly negative relationship between the stream classification of full support and mussel diversity. Of the 17 streams considered full support, 9 streams were classified Restricted or Limited, 6 were Moderate, and 2 were Highly Valued based on the current MCI values. Of the four streams that were considered aquatic life impaired, two were classified as Limited and two were classified as Moderate.

While two intensive surveys have been conducted on the mainstem Embarras River, nearly 40% (20 of 51) of the sites sampled during this survey had no previous mussel data. Extant mussel populations ranging from 1 to 15 species were found at 13 of these sites. Furthermore, at 50% of the sites with historic data available (16 of 31), the 2009-2011 survey turned up as many or more species than were historically known. The mussel communities collected at these sites suggest relatively intact freshwater mussel communities, since the number of extant species was greater than or nearly the same as historic species records or relict shell collected. Although many threatened, endangered, and rare species have been lost from this basin, unique mussel communities still persist in many locations.

The 13 sites considered Highly Valued or Unique Mussel Resources were all located in the upper to middle portion of this basin. Six of these sites were located on the mainstem

Embarras River. Other Highly Valued sites include the Embarras tributary sites of the East Branch Embarras, Deer Creek, Brushy Fork, Hickory Grove, and North Fork Embarras and one minor Wabash tributary, Brouilletts Creek. In contrast to this, many of the sites with Limited, Restricted, and no mussels found were located in the lower reaches of the basin. While Durham (1993) determined that the streams in this basin tend to be less susceptible to disturbance, Cummings (1988) reported a severe decline in the number of mussels in the mainstem Embarras River. Our survey indicated comparable results to Cummings (1988) regarding individuals and species collected, however, many of the mussel communities were dominated by older individuals possibly past reproductive age. Historical surveys followed by continuous monitoring are an invaluable tool for understanding species shifts that occur during changing landscapes. Our recent findings indicate that the upper and middle portions of this basin maintain relatively intact freshwater mussel communities and should be protected from further disturbance.

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**Table1.** 2009-2011 Embarras and minor Wabash tributaries Intensive Basin Survey. Types of samples include MU-mussel sampling, BE-boat electrofishing, ES-electric fish seine, SH-fish seine hauls, FF-fish flesh contaminate, H-habitat, M-macroinvertebrate, W-water chemistry, and D-Discharge. Sites where a 16-hour sample was completed are noted with an asterisk (\*).

Site Number	IEPA Code	Stream	Types of Samples	County	Location	Watershed Area (km <sup>2</sup> )
Middle Wabash Tributaries						
1	BH-05	Mill Creek	MU,ES,M,H,D,W	Clark	Grand Turn Rd Bridge; 2 miles SW of Hatton	275.57
2	BJ-01	Big Creek	MU,ES,M,H,D,W	Clark	Bridge; 5 miles SE of Marshall	272.70
3	BM-01	Sugar Creek-North.	MU,ES,M,H,D,W	Edgar	Elbridge-Vermilion Rd bridge	132.93
4	BM-02	Sugar Creek-North.	MU	Edgar	2 miles SE of Elbridge near state line	174.23
5	BN-04	Brouilletts Creek	MU,ES,M,H,D,W	Edgar	500E Bridge; 3.8 miles W of St. Bernice, IN	342.48
6	BNB-01	Crabapple Creek/N Fork Brouilletts	MU,ES,M,H,D,W	Edgar	950N Bridge; 3 miles S/3.5 miles E Chrisman	109.39
7	BNBB-01	Salt Fork Brouilletts Creek	MU,ES,M,H,D,W	Edgar	1850th Rd; 7.0 miles SE Chrisman	125.73
8	BZO-01	Hutson Creek	MU,ES,M,H,D,W	Crawford	2 miles S of Hutsonville	62.79
Embarras River basin						
9	BE-25	Embarras River	MU,ES,M,H,D,W	Champaign	5 miles NE of Pesotum	114.46
10	BET-01	East Branch Embarras River	MU,ES,M,H,D,W	Champaign	Co Rd 100 N; 2 miles N of Villa Grove	140.48
11	BES-01	Jordan Slough	MU,ES,M,H,D,W	Douglas	Co Rd 1700 E; N side of Villa Grove	108.27
12	BE-14	Embarras River	MU,BE,FF,M,H,D,W	Douglas	1000N bridge; W of Camargo	461.43
13*	BE-19	Embarras River	MU	Douglas	Twp Rd; 2.75 miles S of Camargo	489.60
14	BERB-01	Hackett Branch	MU,ES,M,H,D,W	Douglas	Co Rd 800 N; 2.5 miles SE of Tuscola	113.72
15	BER-03	Scattering Fork	MU	Douglas	1275E Bridge; 4.0 miles N of Filson	251.92
16	BEZZ-05	Brushy Fork	MU	Douglas	2200E; 4.3 miles SW of Newman	298.64
17*	BEZZ-02	Brushy Fork	MU	Douglas	Twp. Rd. bridge; 5 miles NE Hindsboro	315.94
18	BEZY-01	Deer Creek	MU,ES,M,H,D,W	Douglas	Co. Rd. 1900E; 1.5 miles NE of Hindsboro	68.93
19	BE-38	Embarras River	MU	Coles	Boyd Ford; 3.8 miles SW of Oakland	1377.86
20	BEPH-01	Hickory Grove	MU,ES,M,H,D,W	Edgar	400th St; 2.0 miles NW of Redmon	67.48
21	BEPD-01	Catfish Creek	MU,ES,M,H,D,W	Edgar	1425th Rd; 4.0 miles NW of Redmon	134.87
22	BEP-01	Donica Creek	MU,ES,M,H,D,W	Coles	2700E; 2.5 miles SE of Oakland	65.15
23*	BEP-01	Little Embarras	MU	Coles	4.5 miles NNW of Ashmore	307.18
24	BEO-01	Polecat Creek	MU,ES,M,H,D,W	Coles	2150E Bridge; 3.5 miles SW of Ashmore	69.28
25	BE-96	Embarras River	MU,BE,SH,FF,M,H,D,W	Coles	0.25 miles ds Lake Charleston	2005.19
26*	BEN-02	Kickapoo Creek	MU	Coles	2 miles W of Charleston	69.00
27	BENC-01	Cassel Creek	MU,ES,M,H,D,W	Coles	Polk Ave Bridge; 1.2 miles W of Charleston	69.49
28	BENA-03	Riley Creek	MU,ES,M,H,D,W	Coles	Polk Ave Bridge; 1.2 miles W of Charleston	103.78
29	BENA-01	Riley Creek	MU,ES,M,H,D,W	Coles	Twp. Rd. bridge; 0.5 miles W of Charleston	166.02
30	BEN-01	Kickapoo Creek	MU,ES,M,H,D,W	Coles	1520E/600N Bridge; 1.0 mile SSW of Charleston	250.85
31	BE-09	Embarras River	MU	Cumberland	Ryan Bridge; 6 miles NE of Toledo	2344.32
32	BEL-01	Hurricane Creek	MU,ES,M,H,D,W	Cumberland	Rt. 130 bridge; 4.0 miles N of Greenup	147.09
33	BE-37	Embarras River	MU	Cumberland	River Road; 3.0 miles SW of Greenup	2617.43
34	BEJ-06	Muddy Creek (North)	MU	Cumberland	600N Bridge; 4.7 miles N of Woodbury	157.29
35	BEH-01	Mint Creek	MU,ES,M,H,D,W	Jasper	760E; 4.3 miles ENE of Wheeler	49.82
36	BE-35	Embarras River	MU	Jasper	Canoe launch at Newton Park	3548.08
37	BE-07	Embarras River	MU,BE,M,H,W	Jasper	County road bridge at Ste. Marie	3864.84
38	BEF-08	North Fork Embarras River	MU,ES,M,H,D	Clark	1.5 miles NW Martinsville	232.42
39*	BEF-02	North Fork Embarras River	MU	Clark	Twp Rd; 5 miles SE of Casey	383.15
40	BEF-04	North Fork Embarras River	MU	Jasper	E 1700th Avenue; 7.6 miles NNW of Oblong	465.69
41	BEF-03	North Fork Embarras River	MU,W	Jasper	Rt 33; W of Oblong	821.14
42	BEF-05	North Fork Embarras River	MU,BE,SH,M,H,D,W	Crawford	Co. Rd Bridge; 2.5 miles W Oblong	821.14
43	BED-03	Big Creek	MU,ES,M,H,D,W	Crawford	4 miles E and 2 miles N Oblong	74.13
44	BEB-05	Brushy Creek	MU,ES,M,H,D,W	Lawrence	1650 N Bridge; 6 miles N Lawrenceville	119.57
45	BE-03	Embarras River	MU,BE,SH,M,H,W	Lawrence	Il. Rt. 1 bridge; N edge of Lawrenceville	5940.78
46	BEZB-07	Indian Creek	MU,ES,M,H,D,W	Lawrence	Il. Rt. 1 Bridge; 1.5 miles S of Lawrenceville	77.07
47	BEZF-01	Allison Ditch	MU,ES,M,H,D,W	Lawrence	Co. Rd 13 Bridge; 2.25 miles E Billet	80.52
Lower Wabash Tributaries						
48	BZK-01	Raccoon Creek	MU,ES,M,H,D,W	Lawrence	050N; 4 miles WSW Francisville	159.01
49	BC-04	Bonpas Creek	MU,ES,M,H,D,W	Edwards	2320N; 5 miles N West Salem	152.47
50	BC-02	Bonpas Creek	MU	Edwards	Rt 15 Bridge; 0.6 miles NE of Browns	582.38
51	BB-01	French Creek	MU	White	2400N Bridge; 2 miles SW of Grayville	37.26

**Table 2.** Mussel data for sites sampled during 2009-2011 surveys (Table 1). Numbers in columns are live individuals collected; "D" and "R" indicates that only dead or relict shells were collected. Shaded boxes indicate historic collections at the specific site location obtained from the INHS Mollusk Collection records. Species in bold are federally or state-listed species or species in Greatest Need of Conservation by IL DNR. Proportion of total is number of individuals of a species divided by total number of individuals at all sites. Extant species is live + dead shell and total species is live + dead + relict shell. NDA represents no historical data available. MCI scores and Resource Classification are based on values in Tables 3 and 4 (R= Restricted, L= Limited, M= Moderate, HV= Highly Valued, and U= Unique). \*includes *Anodonta suborbiculata*, *Simpsonia ambigua*, *Pleurobema clava*, *Quadrula cylindrica*, and *Cyprogenia stegaria*, which are not represented in the table.

Species	Site Number																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Subfamily Anodontinae																									
<i>Alasmidonta marginata</i>																	1								
<i>Alasmidonta viridis</i>							R																		
<i>Anodontoides ferussacianus</i>						D	R		R		1			D	D			6		12	1	3			
<i>Arcidens confragosus</i>																									
<i>Lasmigona complanata</i>					R	D	R			5	1	35	4	6	7	2	3	2	6	1	3		3	R	10
<i>Lasmigona compressa</i>						R								R				1				R			
<i>Lasmigona costata</i>												R	R						2						
<i>Pyganodon grandis</i>										2	R	7	2	R	2	2	2	147	12	3	7				16
<i>Strophitus undulatus</i>				1			R			1		1	1	D	R	R	2		R					R	R
<i>Utterbackia imbecillis</i>																									
Subfamily Ambleminae																									
<i>Amblema plicata</i>					R	R	R					R	R			81	11		R				R	R	2
<i>Elliptio dilatata</i>														R											
<i>Fusconaia ebena</i>																									
<i>Fusconaia flava</i>					10	D				30		10	4			11	5	1	5		16		37		1
<i>Megalonaias nervosa</i>												1							3						
<i>Plethobasus cyphus</i>																									
<i>Pleurobema rubrum</i>																									
<i>Pleurobema sintoxia</i>										2		42	57			4	8		30				D		
<i>Quadrula metanevra</i>																									
<i>Quadrula nodulata</i>																									
<i>Quadrula pustulosa</i>										4		61	63						71				2		16
<i>Quadrula quadrula</i>												R	1				1		4						7
<i>Tritogonia verrucosa</i>										11		21	12			6	R		28						6
<i>Unio merus tetralasmus</i>				R	R			1			R			D	R			6		1		R			
Subfamily Lampsilinae																									
<i>Actinonaias ligamentina</i>																									
<i>Ellipsaria lineolata</i>																									
<i>Epioblasma triquetra</i>																									
<i>Lampsilis cardium</i>	D	R	R		18	D				1	3	27	1	R	1	4	R		15		1		9		1
<i>Lampsilis siliquoidea</i>			R		23	D				60	17	17	1	D		9	1	4	R	13	52	6	18	R	R
<i>Lampsilis teres</i>	R				3																				
<i>Leptodea fragilis</i>				D	5					1		7	4				6		16			7			8
<i>Ligumia recta</i>																									
<i>Ligumia subrostrata</i>																									
<i>Obliquaria reflexa</i>																									
<i>Obovaria subrotunda</i>																									R
<i>Potamilus alatus</i>					D																				20
<i>Potamilus ohioensis</i>																									4
Ptychobranchus fasciolaris																									
<i>Toxolasma lividum</i>																			1						
<i>Toxolasma parvum</i>																									
<i>Toxolasma texasiensis</i>																									
<i>Truncilla donaciformis</i>																									
<i>Truncilla truncata</i>																									
<i>Villosa fabalis</i>																									
<i>Villosa lienosa</i>						D	R																		
										3	2	R	R	R		2	D	2		4	3		D	R	
Individuals	0	0	0	0	61	0	0	10	0	122	24	234	161	6	10	123	42	188	199	41	83	10	76	0	104
Live Species	0	0	0	0	7	0	0	2	0	12	5	12	12	1	3	11	11	9	13	7	7	3	6	0	14
Extant Species	1	0	0	1	9	5	0	3	0	13	5	12	12	6	4	11	13	9	13	7	7	3	8	0	14
Total Species	2	1	2	2	12	9	5	3	2	13	7	16	15	11	6	13	15	9	17	7	7	5	9	5	17
Historical Species	3	NDA	NDA	NDA	8	10	NDA	NDA	NDA	NDA	NDA	7	10	9	8	12	NDA	1	23	5	NDA	2	12	11	22
Catch per unit effort (CPUE)	0	0	0	0	15.25	0	0	2.46	0.00	30.50	6.00	58.21	10.06	1.54	2.56	30.60	2.62	47.00	49.50	10.25	20.75	2.50	4.75	0.00	26.00
Mussel Community Index (MCI)	0	0	0	0	13	0	0	9	0	15	9	13	14	7	7	15	13	14	17	13	11	6	10	0	12
Resource Classification	R	R	R	R	HV	R	R	M	R	HV	M	HV	HV	L	L	HV	HV	HV	U	HV	M	L	M	R	HV

Table 2, continued

Species	Site Number																									Proportion of total
	26	27	28	29	30	31	33	34	35	36	37	38	39	40	41	42	43	45	46	47	48	49	50	51		
Subfamily Anodontinae																									0.04%	
<i>Alasmidonta marginata</i>																									—	
<i>Alasmidonta viridis</i>																									—	
<i>Anodontoides ferussacianus</i>	2	R	1	D	D			1				R	7	3											1.54%	
<i>Arcidens confragosus</i>																							1	R	0.04%	
<i>Lasmigona complanata</i>			3	2		3	6			4	2		19	23	1	1			3		2		R		6.53%	
<i>Lasmigona compressa</i>		R	1	1																					0.12%	
<i>Lasmigona costata</i>										R															0.08%	
<i>Pyganodon grandis</i>															R	1			2		17		7	R	9.53%	
<i>Strophitus undulatus</i>	R		R	2	R									D											0.33%	
<i>Utterbackia imbecillis</i>										1									D						0.04%	
Subfamily Ambleminae																										
<i>Amblema plicata</i>			1				R				R									R			R		3.95%	
<i>Elliptio dilatata</i>																									—	
<i>Fusconaia ebena</i>																									—	
<i>Fusconaia flava</i>	R										1			23											6.41%	
<i>Megaloniais nervosa</i>																									0.17%	
<i>Plethobasus cyphus</i>																									—	
<i>Pleurobema rubrum</i>											R														—	
<i>Pleurobema sintoxia</i>											R						R								5.95%	
<i>Quadrula metanevra</i>																									—	
<i>Quadrula nodulata</i>										17	9			1		1		3							1.29%	
<i>Quadrula pustulosa</i>						12	6			1															9.82%	
<i>Quadrula quadrula</i>						3	8			2				76	7	5			2	3			17		5.66%	
<i>Tritogonia verrucosa</i>					D		8			3	3			1		R									4.12%	
<i>Unio merus tetralasmus</i>		R	R					1	R			R						R		1		R		5	0.62%	
Subfamily Lampsilinae																										
<i>Actinonaias ligamentina</i>							1			R	R														0.04%	
<i>Ellipsaria lineolata</i>																									—	
<i>Epiblasma triquetra</i>																									—	
<i>Lampsilis cardium</i>	R		109	18	2	5	14			4	D		16	19	1	1									11.23%	
<i>Lampsilis siliquoidea</i>			5					1		R			103	38								6			15.56%	
<i>Lampsilis teres</i>						4	3			6	R			1	3	6		R	D		11				1.54%	
<i>Leptodea fragilis</i>						1	12			4	1		2	4	3	11		R					2		3.91%	
<i>Ligumia recta</i>																									—	
<i>Ligumia subrostrata</i>																			2						0.08%	
<i>Obliquaria reflexa</i>							1			1										1					0.12%	
<i>Obovaria subrotunda</i>																									—	
<i>Potamilus alatus</i>			1			7	8			D															1.50%	
<i>Potamilus ohioensis</i>						2	1			R						2									0.37%	
<i>Ptychobranchus fasciolaris</i>											R														0.08%	
<i>Toxolasma lividum</i>																									0.12%	
<i>Toxolasma parvum</i>		R						8			1	R	61	1	1	1	1		15		9		2	13	6.32%	
<i>Toxolasma texasiensis</i>																						1			0.04%	
<i>Truncilla donaciformis</i>						2	8			1	D														0.50%	
<i>Truncilla truncata</i>						3	3			D							R						R		1.66%	
<i>Villosa fabalis</i>																									—	
<i>Villosa lienosa</i>																									0.67%	
																									Total	
Individuals	2	0	121	23	2	42	79	11	0	44	17	0	208	190	16	29	1	3	25	4	39	7	29	18	2404	
Live Species	1	0	7	4	1	10	13	4	0	11	6	0	6	11	6	9	1	1	6	2	4	2	5	2	34	
Extant Species	1	0	7	5	3	10	13	4	0	13	8	0	6	12	7	9	1	2	8	2	4	2	5	2	34	
Total Species	4	4	9	5	4	10	14	4	1	18	14	3	6	12	7	12	2	4	8	3	4	3	8	3	38	
Historical Species	1	NDA	8	NDA	11	22	16	1	NDA	25	10	NDA	7	NDA	11	NDA	NDA	20	5	NDA	NDA	1	6	NDA	49	
Catch per unit effort (CPUE)	0.50	0.00	30.25	5.75	0.50	10.45	19.36	2.75	0.00	10.78	4.17	0.00	13.00	47.50	3.94	7.25	0.25	0.75	6.16	1.00	9.61	1.72	7.14	4.43		
Mussel Community Index (MCI)	4	0	10	7	4	10	13	7	0	12	11	0	11	13	8	11	4	4	11	6	10	6	10	9		
Resource Classification	R	R	M	L	R	M	HV	L	R	HV	M	R	M	HV	M	M	R	R	M	L	M	L	M	M		

**Table 3.** Mussel Community Index (MCI) parameters and scores.

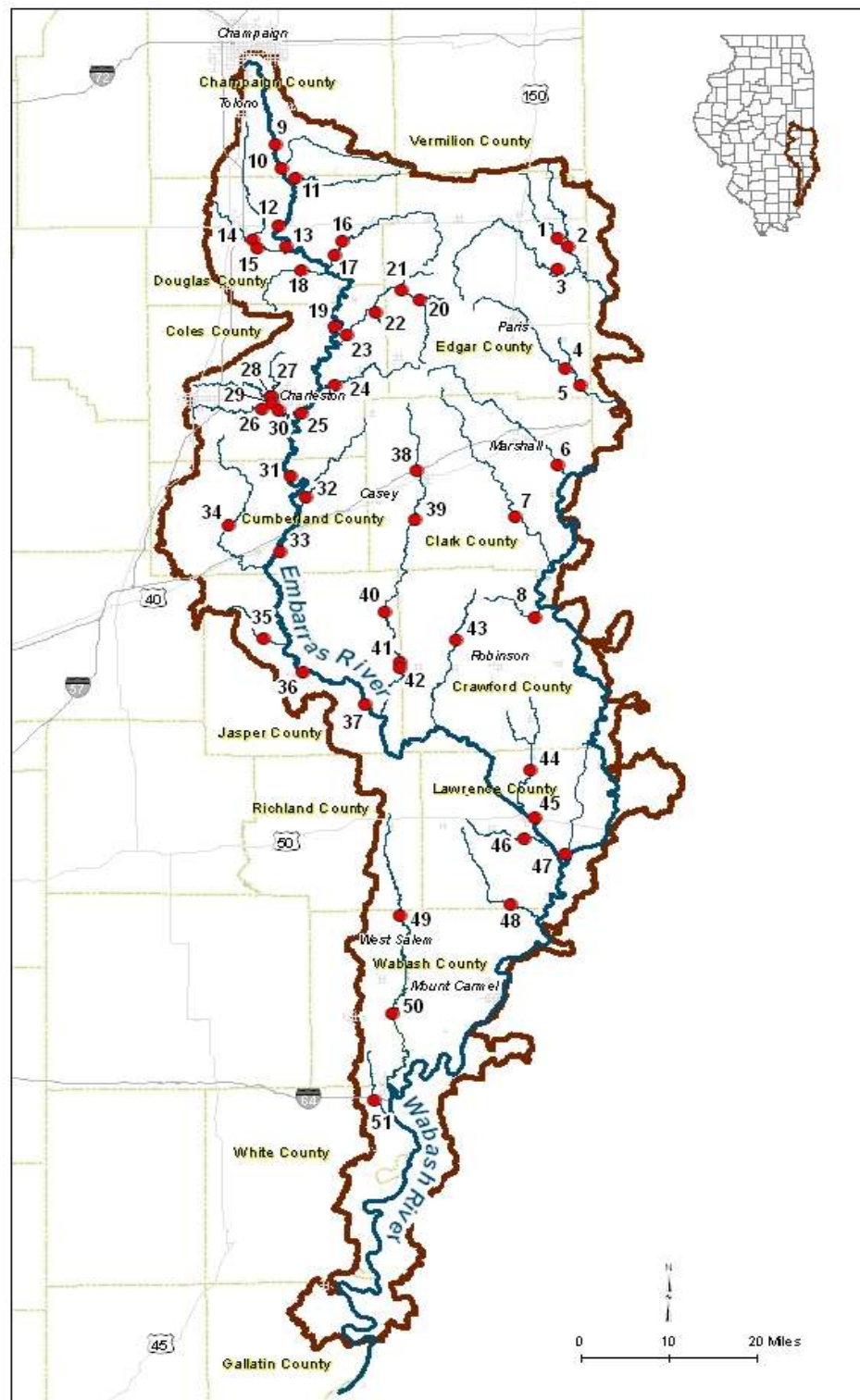
Extant species in sample	Species Richness	Catch per Unit Effort (CPUE)	Abundance (AB) Factor
0	1	0	0
1-3	2	1-10	2
4-6	3	>10-30	3
7-9	4	>30-60	4
10+	5	>60	5
% live species with recent recruitment	Reproduction Factor	# of Intolerant species	Intolerant species Factor
0	1	0	1
1-30	3	1	3
>30-50	4	2+	5
>50	5		

**Table 4.** Freshwater mussel resource categories based on species richness, abundance, and population structure. MCI = Mussel Community Index Score

Unique Resource MCI $\geq 16$	Very high species richness (10 + species) &/or abundance (CPUE > 80); intolerant species typically present; recruitment noted for most species
Highly Valued Resource MCI = 12- 15	High species richness (7-9 species) &/or abundance (CPUE 51-80); intolerant species likely present; recruitment noted for several species
Moderate Resource MCI = 8 - 11	Moderate species richness (4-6 species) &/or abundance (CPUE 11-50) typical for stream of given location and order; intolerant species likely not present; recruitment noted for a few species
Limited Resource MCI = 5 - 7	Low species richness (1-3 species) &/or abundance (CPUE 1-10); lack of intolerant species; no evidence of recent recruitment (all individuals old or large for the species)
Restricted Resource MCI = 0 - 4	No live mussels present; only weathered dead, sub-fossil, or no shell material found

**Table 5.** Mussel data for sites sampled during 1956, 1988 and 2009-2011 (Table 1). Numbers in columns are live individuals collected; "D", "R", and "X" (1956, 1988) indicates that only dead or relict shells were collected. Shaded boxes indicate historic collections at the specific site location obtained from the INHS Mollusk Collection records. Species in bold are federally or state-listed species or species in Greatest Need of Conservation by IL DNR. Extant species is live + dead shell and total species is live + dead + relict shell.

	Site 9			Site 13			Site 19			Site 25			Site 31			Site 33			Site 36			Site 37			Site 45		
Species	1956	1986	2011	1956	1986	2011	1956	1986	2011	1956	1986	2011	1956	1986	2011	1956	1986	2011	1956	1986	2011	1956	1986	2011	1956	1986	2011
<b>Subfamily Anodontinae</b>																											
<i>Alasmidonta marginata</i>								2																			
<i>Alasmidonta viridis</i>																											
<i>Anodontoides ferussacianus</i>		X	R										13						2								
<i>Arcidens confragosus</i>																											
<i>Lasmigona complanata</i>						4		6	6		3	10	5	1	3		22	6	13	5	4		1	2	13		
<i>Lasmigona compressa</i>																											
<i>Lasmigona costata</i>						R	14	2	2		X						3				R						
<i>Pyganodon grandis</i>				X	X	2	2	4	12		X	16	3						3								
<i>Strophitus undulatus</i>					X	1		8	R	N		R	9			N	1		6	X		N					
<i>Utterbackia imbecillis</i>										O						O			1		1	O					
<b>Subfamily Ambleminae</b>										T						T						T					
<i>Amblema plicata</i>						R	1		R		15	2	1				2	R	8				X	R			
<i>Cyclonaias tuberculata</i>										C						C					R	C					
<i>Elliptio dilatata</i>										O						O						O					
<i>Fusconaia ebena</i>										L						L						L					
<i>Fusconaia flava</i>				1	X	4	13	1	5	L	2	1	1	X		L	X		20	X		L		1	9	X	
<i>Megalanaia nervosa</i>								X	3	E	1					E						E					
<i>Plethobasus cyphus</i>										C						C						C					
<i>Pleurobema rubrum</i>										T						T						T		R			
<i>Pleurobema sintoxia</i>					X	57	23	7	30	E						E						E		R			
<i>Quadrula metanevra</i>							4	1		D						D						D				X	
<i>Quadrula nodulata</i>																			144	2	17		2	9	7	X	3
<i>Quadrula pustulosa</i>					X	63	10	33	71		46	16	15		12		26	6	35	X	1				2		
<i>Quadrula quadrula</i>					X	1	2	6	4		51	7	12		3		32	8	172	X	2		X		5		
<i>Tritogonia verrucosa</i>					X	12	2	8	28		15	6	1				18	8	1	X	3		X	3			
<i>Unio merus tetralasmus</i>																											
<b>Subfamily Lampsillinae</b>																											
<i>Actinonaias ligamentina</i>							14	2			1		17	X			38	1	14	3	R		X	R		X	
<i>Ellipsaria lineolata</i>																											
<i>Epiblasma triquetra</i>							2	7		X																	
<i>Lampsilis cardium</i>						1	23	49	15		10	1	64	X	5		24	14	42	11	4		X	D	9		
<i>Lampsilis siliquoidea</i>				1	X	1	2	14	R		2	R	1	X			3		17		R						
<i>Lampsilis teres</i>													6	X	4		1	3	30	X	6		1	R	52		R
<i>Leptodea fragilis</i>						4			16		2	8		X	1		19	12	7	15	4		X	1	19	3	R
<i>Ligumia recta</i>																				X							
<i>Ligumia subrostrata</i>																											
<i>Obliquaria reflexa</i>																		1			1						
<i>Obovaria subrotunda</i>							1								R				36								
<i>Potamilus alatus</i>											2	20			7		2	8		3	D				1		
<i>Potamilus ohioensis</i>										X	4			2			1	1			R				8	X	
<i>Ptychobranhus fasciolaris</i>							8	1	1															R		X	
<i>Toxolasma lividum</i>																											
<i>Toxolasma parvum</i>			R		X	X						2												1	2		
<i>Toxolasma texasiensis</i>																											
<i>Truncilla donaciformis</i>												1			2			8			1			D	5	10	
<i>Truncilla truncata</i>						11			6		X	10		1	3		3	3		X	D						
<i>Villosa fabalis</i>																											
<i>Villosa iris</i>						X			R																		
<i>Villosa lienosa</i>					X	X	R	1	X																		
Individuals	0	0	0	2	0	161	122	151	199	0	150	104	148	2	42	0	195	79	551	39	44	0	4	17	132	13	3
Live Species	0	0	0	2	0	12	16	16	13	0	12	14	13	2	10	0	15	13	17	6	11	0	3	6	12	2	1
Extant Species	0	1	0	3	13	12	0	2	13	0	5	14	0	6	10	0	1	13	0	11	13	0	5	8	0	7	2
Total Species	0	1	2	5	13	15	16	18	17	0	17	17	13	8	10	0	16	14	17	17	18	0	8	14	12	9	4



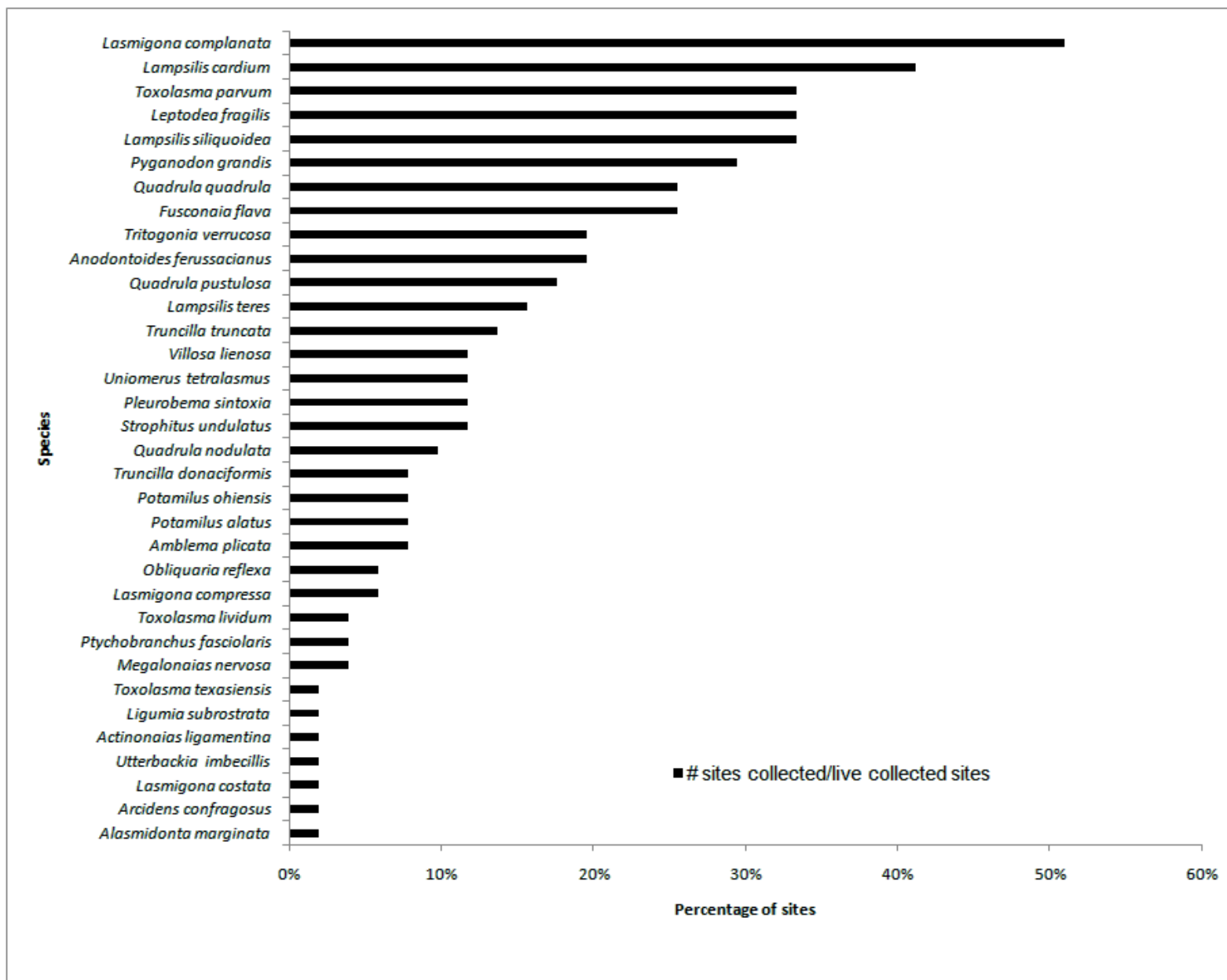
**Figure 1.** Sites sampled in the Embarras River basin and Wabash Tributaries during 2009-2011. Site codes referenced in Table 1.



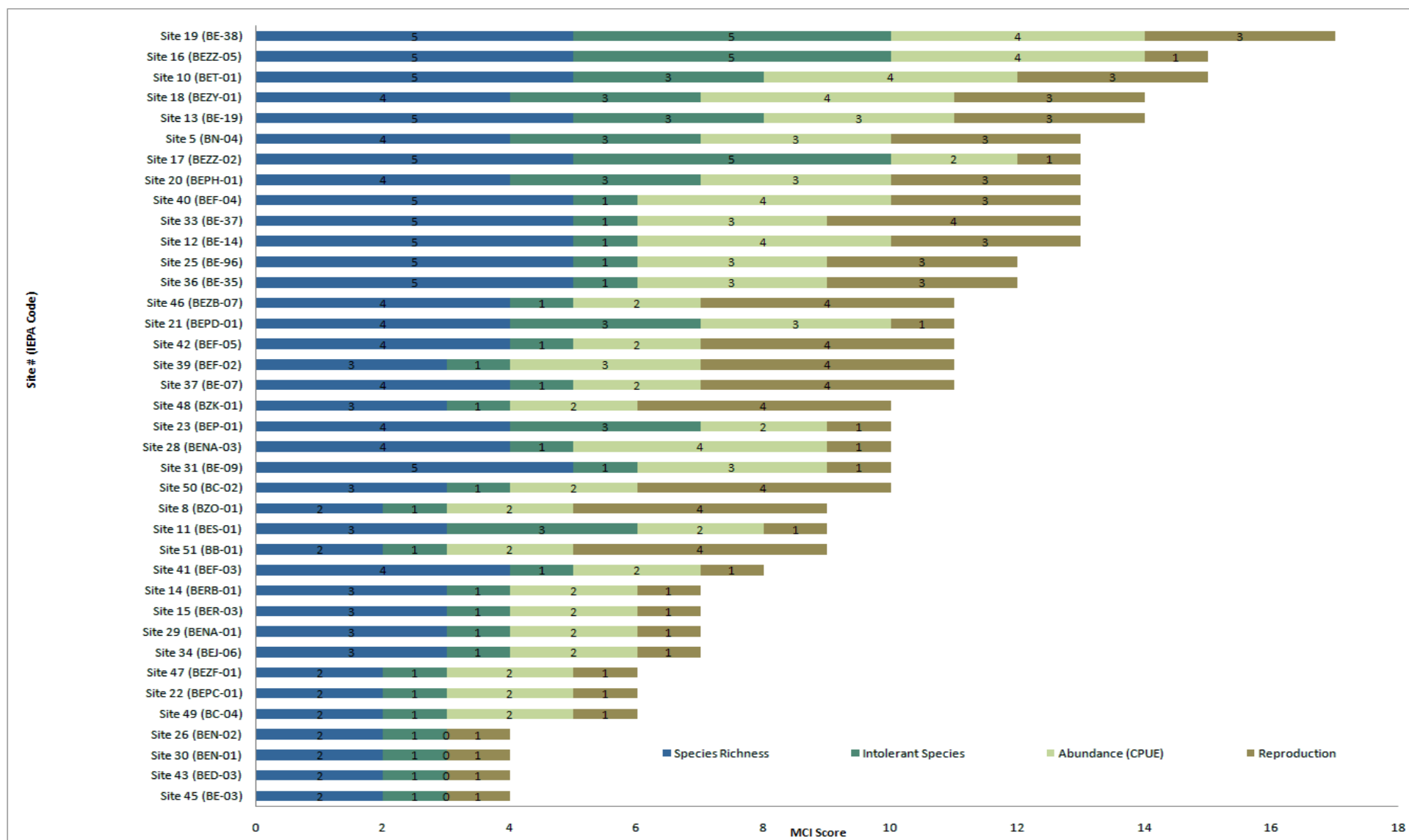
**Figure 2.** Upstream portion of East Branch Embarras, site 10, unmodified riparian, various habitat types in stream.



**Figure 3.** Upstream portion of Embarras River, site 37, expansive, exposed sand bar.



**Figure 4.** Number of sites where a species was collected live compared to the number of sites sampled (51 total sites).



**Figure 5.** Comparison of Mussel Community Index (MCI) and MCI component scores for Embarras River and minor Wabash tributary sites based on factor values from Table 3.



**Figure 6.** Kidneyshell (*Ptychobranchus fasciolaris*) collected in the Embarras River basin.



**Figure 7.** Purple lilliput (*Toxolasma lividum*) collected in the Embarras River basin.

Appendix 1. Scientific and common names of species. Status (in 2012): FE- federally endangered, SE- state-endangered, ST-state threatened, SGNC-Illinois' species in greatest need of conservation, X-extirpated.

Scientific name	Common name	Status
<b>Subfamily Anodontinae</b>		
<i>Alasmidonta marginata</i>	elktoe	
<i>Alasmidonta viridis</i>	slippershell mussel	ST
<i>Anodonta suborbiculata</i>	flat floater	
<i>Anodontoides ferussacianus</i>	cylindrical papershell	
<i>Lasmigona complanata</i>	white heelsplitter	
<i>Lasmigona compressa</i>	creek heelsplitter	SGNC
<i>Lasmigona costata</i>	flutedshell	SGNC
<i>Pyganodon grandis</i>	giant floater	
<i>Simpsonaias ambigua</i>	salamander mussel	SE
<i>Strophitus undulatus</i>	creeper	
<i>Utterbackia imbecillis</i>	paper pondshell	
<b>Subfamily Ambleminae</b>		
<i>Amblema plicata</i>	threeridge	
<i>Elliptio dilatata</i>	spike	ST
<i>Fusconaia ebena</i>	ebonyshell	ST
<i>Fusconaia flava</i>	Wabash pigtoe	
<i>Megaloniaias nervosa</i>	washboard	
<i>Plethobasus cyphus</i>	sheepnose	FE
<i>Pleurobema clava</i>	clubshell	FE
<i>Pleurobema rubrum</i>	pyramid pigtoe	X
<i>Pleurobema sintoxia</i>	round pigtoe	
<i>Quadrula cylindrica</i>	rabbitsfoot	SE
<i>Quadrula metanevra</i>	monkeyface	SGNC
<i>Quadrula nodulata</i>	wartyback	
<i>Quadrula pustulosa</i>	pimpleback	
<i>Quadrula quadrula</i>	mapleleaf	
<i>Tritogonia verrucosa</i>	pistolgrip	
<i>Unio merus tetralasmus</i>	pondhorn	
<b>Subfamily Lampsilinae</b>		
<i>Actinonaias ligamentina</i>	mucket	
<i>Cyprogenia stegaria</i>	fanshell	FE
<i>Ellipsaria lineolata</i>	butterfly	ST
<i>Epioblasma triquetra</i>	snuffbox	FE
<i>Lampsilis cardium</i>	plain pocketbook	
<i>Lampsilis siliquioidea</i>	fatmucket	
<i>Lampsilis teres</i>	yellow sandshell	
<i>Leptodea fragilis</i>	fragile papershell	
<i>Ligumia recta</i>	black sandshell	ST
<i>Ligumia subrostrata</i>	pondmussel	
<i>Obliquaria reflexa</i>	threehorn wartyback	
<i>Obovaria subrotunda</i>	round hickorynut	SE
<i>Potamilus alatus</i>	pink heelsplitter	
<i>Potamilus ohioensis</i>	pink papershell	
<i>Ptychobranhus fasciolaris</i>	kidneyshell	SE
<i>Toxolasma lividum</i>	purple lilliput	SE
<i>Toxolasma parvum</i>	lilliput	
<i>Toxolasma texasiensis</i>	Texas lilliput	
<i>Truncilla donaciformis</i>	fawnsfoot	
<i>Truncilla truncata</i>	deertoe	
<i>Villosa fabalis</i>	rayed bean	SE, X
<i>Villosa lienosa</i>	little spectaclecase	ST